

Another consequence of a strong research school will be to attract from outside those engaged in industry who have special problems of their own to solve which cannot be so well dealt with in the laboratories to which they have access in works or elsewhere. This should, of course, receive encouragement. The introduction of outsiders of the right kind to the laboratories is of service in several ways. It "spreads the light" by keeping industrials informed as to the progress of science and the improvements of methods of investigation, and as to the precise nature, cost, and limitations of scientific inquiry. It impresses upon them the necessity for experimental accuracy, and shows how closely the sciences are now interwoven, and how results obtained in one science or branch may be imported to assist progress in another. Better relations are established between the institution and the industries surrounding it, mutual confidence is engendered, and personal acquaintance is encouraged to the advantage, on one hand, of the industries, and, on the other, of the students who may find eventual employment therein.

A corollary is that in certain cases research by staff or students may be in part carried on in works laboratories outside the university, and the considerations just set out apply as well to this case. Care is requisite that industrial research should not degenerate into anything of the nature of routine or testing work. This should be excluded, and the universities should not in any way compete with firms which specialise in this direction. Only where this class of work involves problems which are new or exceptionally difficult, or need the employment, or even formulation, of new principles, should it be undertaken by university departments.

The Product.

The type of man which it should be the aim of the universities to turn out should possess those qualities which distinguish the best type of scientific man—not merely knowledge of his subject and technical ability to use that knowledge, but capability to introduce the scientific method into his conduct of everyday life and into his dealings with his colleagues and subordinates. He must be willing to study *all* the conditions of his problems before he is sufficiently satisfied with their solution to carry them into effect. These conditions require, not *a* solution, but *the* solution which can be brought into operation with the least possible disturbance of the things that are, without needless change of raw material, machinery, or *personnel*, but with the advantage of diminished cost, enlarged production, and increased value or efficiency.

If this is the aim, the product will be the best type of technologist. He will not necessarily be the type of man suited to occupy immediately the highest position in his business. But the work given him to

perform will be so well done that it will be impossible for his character, competence, and ability long to escape the watchful attention of his chiefs. It will not be long before he is chosen for more and more responsible work until he attains high rank in his profession. I do not believe it is possible that men of managerial type, captains of industry, will ever be technically trained as such. The universities should endeavour to produce such a type of man that his superiors will take him by force, and almost against his will, from his technological work to direct the bigger issues.

Conclusions.

(1) As much as in any other walk of life, the education of the business man must be a liberal one. His mind must be as agile, and he must be as well provided with intellectual weapons, as any other well-educated man.

(2) A course of technological education thoughtfully laid out is, as an instrument for mind-training and in the nature of the product turned out, in no way inferior to the higher branches of language, literature, history, or philosophy. The work is as hard, the problems to be solved as difficult, the reasoning as acute, the intellectual joy in success as great; while its urgency to the nation and to mankind is one of the most pressing matters that educationists have to face.

(3) In the multiplicity and complexity of subjects there is no longer time for the most liberal of educations to be as broad as heretofore. Some universities are even specialising in a single dead language as an honours subject, holding, perhaps rightly, that a thorough knowledge of one is better than what can be attained, in the time available, of two. Technological education has anticipated this specialisation only by a few years.

(4) There is no less worthiness and dignity in the newer education than in the old. All higher education is, and always has been, technological. The learning of the older universities has been used, and has even been moulded for the purpose, to equip the parson, the poet, and the politician; and both the peer and the proletarian can gain from the study of classical literature some facts or theories to guide them in their respective vocations.

(5) The business man has good right to demand that institutions of university rank shall supply his demands as well as they have dealt with education for the professions. The polytechnic system has not had the success that was expected in educating his foremen and workmen. He must not be again disappointed when he seeks higher education for himself. He expects, and has a right to expect, that the type of education he needs shall be, not a by-product or a by-product, but a worthy aim in itself; and if the universities will not give it to him, he will take his own steps in the matter.

The Exploitation of Irish Peat.¹

By PROF. HUGH RYAN.

THERE are about 6,000,000 tons of turf used every year in Ireland, but this quantity is almost insignificant in comparison with the total amount, about 4,000,000,000 tons, which can be won from the bogs of the country. The Irish Peat Inquiry Committee, of which the present writer was a member, was appointed

to suggest what means should be taken to ascertain the conditions under which the peat could be profitably won, prepared, and used in the most favourably situated localities. The main report of the Committee, which is contained in the publications under notice, recommended the purchase by the State of a large bog in which hand and mechanical methods of winning peat could be tried side by side. These tests would require to be continued over a long period if

¹ "The Winning, Preparation, and Use of Peat in Ireland." Reports and other Documents. (Fuel Research Board. Department of Scientific and Industrial Research, 1921.) 35.

they were to give trustworthy data, and they would have resulted in the winning of large amounts of peat, for which there would be little prospective market. With the view of decreasing the net expense of the experiments and at the same time of testing, on an adequately large scale, the commercial possibility of utilising peat for the generation of electric power, the Committee suggested the installation of an electric power station on a suitable area of the Bog of Allen, within 25 to 40 miles from Dublin. A portion of this power could be used locally to drive the peat-winning machines or agricultural machinery, in chemical industries, such as the manufacture of calcium cyanamide, and for lighting and power purposes in the neighbouring towns. The excess of electric power could be transmitted in bulk to the power station at Dublin.

As a result of a conference with the Fuel Research Board the Irish Committee submitted a much less ambitious, if less satisfactory, scheme, which con-

A serious obstacle which confronts everyone who attempts to devise a scheme for winning peat on a large scale is the labour difficulty. The peat-fuel season, depending on air-drying as it must do for commercial reasons, lasts only about four to six months of an average year. It is not easy, therefore, for the peat industry to attract the labourers required by it from other industries which offer them constant employment throughout the year. This applies especially to the men required for cutting and spreading the peat. Much of the work of the drying operations can be done by women and boys, who are in general available during the late summer months in any more or less thickly populated district. One of the chief problems which the Peat Committee had to consider was, therefore, how to limit so far as possible the number of men necessary for the winning of a definite quantity, say 250 tons, of turf each day of the cutting season (120 days). The same difficulty was experienced abroad, and was, to some extent, met there by the



sisted briefly of the purchase of a bog of about 10,000 acres at a price of about 2*l.* an acre, and the establishment in it of an experimental station to test the various methods proposed for winning peat. Even on this scale a considerable number of labourers would be required, and in order to encourage these to settle in the district the Committee proposed to have experiments conducted by the Department of Agriculture for Ireland on the reclamation of cutaway and virgin bog. The Fuel Research Board approved in general of this scheme in 1918, but the agricultural portion of the scheme was referred to the Irish Department of Agriculture about two years after the Peat Committee had submitted its report. The present publications contain also the report of the Sub-Committee on agricultural matters appointed by the Department of Agriculture. Owing to this unfavourable, and to a large extent unjustifiable, report of the Sub-Committee, it is not proposed to carry into effect the recommendations of the Irish Peat Inquiry Committee with regard to the winning of peat.

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introduction of labour-saving devices such as the automatic machines of the Baumann and Wielandt types.

The Baumann machine consists of a ladder dredger which scrapes the peat off the inclined face of the bank and conveys it to the hopper of the cylindrical mixer and macerator, shown on the right-hand side of Fig. 1. The peat is pressed through the mouth-piece of the macerator as a rectangular band which is automatically cut into sods. The latter are caught on plates moving in a lattice girder, extending about 120 metres over the adjacent drying ground. When the lower half of the continuous chain of plates is completely filled with sods, these are tipped on the drying ground and the emptied plates return to the macerator over the upper portion of the latticed girder. One of these machines in Raubling Bog, Bavaria, attended by a gang of five men, had a daily output of spread sods corresponding to 5½ tons of air-dry turf. Its dredger was driven by a 20-h.p. electro-motor, its macerator by a similar motor of 40 h.p., and the cost of the complete machine was 1500*l.*

The Wielandt machine is similar in principle to the Baumann, but lighter in construction, largely owing to the adoption in it of a different spreading mechanism. The machine can be driven by a 25-h.p. electromotor, and its total cost, including motor and cables, was 1000*l.* four or five years ago, but is now much higher. During the war it was found at Elisabethfehn, in Oldenburg, that one of these machines, attended by one man and three or four youths, had an output in the season of 7000 tons of air-dry turf.

If the statements made abroad with regard to the efficiency of automatic machines are correct, four of these machines, attended by sixteen men in all, can dredge, form into sods, and spread in a day enough

peat to yield, when air-dry, about 250 tons of turf. The same output of peat, cut and spread, by the method ordinarily practised in Ireland requires about 160 men. It is therefore a matter of great importance for the winning of peat on a large scale in Ireland that these claims should be subjected to a prolonged test under the conditions obtaining here. In conclusion the writer must again express his regret that the recommendations of the Peat Inquiry Committee were ultimately set aside for reasons which are in part due to misinterpretation of the Peat Committee's report, and in part to statements which were made by the Agricultural Sub-Committee, and are in sharp disagreement with the actual facts, in regard to the extent and the purchase price of Irish bogs.

See also Aug. 18 p. 779.

Geophysical Problems.

A SURVEY of research problems in geophysics has recently been published by the American Geophysical Union, a body which acts as the Committee on Geophysics of the National Research Council, and as the United States National Committee of the International Geodetic and Geophysical Union. The survey consists of a series of seven essays by the chairmen of the several sections of the union, dealing respectively with geodesy, seismology, meteorology, terrestrial magnetism and electricity, physical oceanography, volcanology, and geological physics and chemistry. It is interesting to observe that the two latter subjects, so little studied in this country, are in America found sufficiently important to occupy separate sections of the union.

Advance in nearly all these branches of geophysics seems to depend on much the same method of attack, involving on the one hand an enormous amount of organised, co-ordinated labour of observation and measurement, and on the other individual theoretical study, necessarily of a freelance character, by a comparatively few people with scientific training, insight, and wide knowledge, at research institutes or universities. The first half of the task is being executed with increasing skill and success by the national scientific organisations of the leading countries, but the complementary half lags behind. Dr. C. F. Marvin, for instance, after describing the present achievements and future tasks of meteorological organisations, concludes that "seemingly the greatest need in meteorology is that of a master mind to direct itself comprehensively and intensively to the great problems which the science still presents." The recency of the beginning made by meteorologists in the study of the upper air, now recognised to be fundamental for the upbuilding of a dynamical science of meteorology, suggests that perhaps also in other geophysical sciences progress may be obstructed by failure to perceive vitally important directions which observation and research must take.

The outstanding task of geodesy at the present time is described by Prof. Bowie as being that of co-ordinating the geodetic triangulations of the various countries by reducing them to a single datum, defined as the adopted latitude and longitude of some one station, the azimuth of a line radiating from that station, and the dimensions of the reference spheroid on which the triangulation is computed. This involves a herculean work of re-computation and readjustment of the triangulation networks, especially in Europe; in America much progress in this direction has already been made. Gravity surveys must be extended over the land surfaces, and a satisfactory method of observation evolved for the ocean areas of

the globe; this will afford information as to the variations of density in the earth's crust, enable the theory of isostasy to be further developed, and thereby lead to ever closer approximations to the figure of the earth.

In seismology the most important world-wide problem is the accurate determination of the time taken by earthquake waves to travel from their origin to other points on the earth's surface; this information is necessary in order that the origin of earthquakes arising in inaccessible (land or oceanic) regions may be determined, and that the velocity and path of the waves within the earth may be deduced, thus throwing light on the earth's internal constitution. Prof. Reid expresses the opinion that the most useful means to this end lies in the improvement of the equipment of existing seismological observatories rather than in multiplication of the present number. The desirability also of methodical studies of limited areas where small shocks are frequent and strong ones occasional is also mentioned, with the view of determining the sequence of events leading up to the rupture producing a strong shock, and possibly of forecasting the region and time of such occurrences.

Dr. Bauer's article on terrestrial magnetism contains some interesting remarks on the progress of the analysis of the earth's magnetic field which is now being made in the department of the Carnegie Institution which he controls. It has been concluded that for many purposes the theoretical formula proceeding in series of spherical harmonics may be restricted to the few most important terms, leaving the residual field, representing continental and more local irregularities, for special study and treatment in accordance with their extent and character. Reference is also made to the important problems afforded by the magnetic variations, both those connected with auroræ and earth-currents, and the rarer ones occurring at times of solar eclipse. The baffling fundamental problems of the origin of the earth's main magnetic field and the cause of its secular variation are also touched upon.

Prof. Littlehales points out the influence which the ocean, being so large an expanse of the substance having the highest known capacity for heat, must exercise as a factor governing the distribution of terrestrial temperature, and the consequent importance of oceanography to geophysics in general. A *résumé* is given of the efforts so far made, by voyages of exploration and by investigations in marine laboratories, towards the study of the oceans in their many aspects; the system according to which progress is now being sought is the study, in detail, of definite oceanic stations periodically revisited every three